VEHICLE LIGHTING

By WHITNEY MATTHEWS, '38

ANYONE who has driven an automobile after dark has been brought face to face with one of the great problems of the illuminating engineers, glare from oncoming cars. Automotive engineers have made an earnest effort to solve this problem by use of dimming, deflecting, or tilting the headlight beam. These methods, however, leave the choice in the hands of the drivers who are so often negligent about the safety and comfort of others. So, in spite of the efforts of the engineers to make this control easy for the driver, the problem has not yet been eliminated.

First, it might be well to set forth the requirements of good automotive headlighting. Automobile headlights should provide an abundance of illumination, so distributed vertically that the road for some distance ahead is uniformly illuminated to a height of at least six feet above the pavement, with the horizonal distribution wide enough to give ample illumination on the sides of the road with proper illumination for both right and left turns. Obviously, if the requirement for the vertical distribution is filled there will be a brilliant light directed into the eyes of the driver of an oncoming car. To reduce this hazard two methods are now in common usage, that is, the reduction of the intensity of the light (dimming), and the redirection or lowering of the beam of light issuing from the headlamp. Both of these methods have immediately obvious disadvantages. Many methods have been devised to overcome these difficulties but in general have many disadvantages due to complicated structure or equipment or violation of the requirements of good lighting practice. These various methods will be considered here only briefly.

A frequency or color selection method has been tried and found satisfactory.[1] This method uses color filters which pass certain light frequencies (colors) but will not allow others to pass through them. It has the disadvantage, however, that it requires different color combinations for cars traveling in opposite directions, and that these filters must be changed to meet the established custom of the road.

A time selection method utilizes synchronized shutters in the lamps and the road is viewed through another set of shutters. The shutter in the headlamp is in time phase with the shutter through which the road is viewed and is directly out of phase with the shutters of an approaching car. Thus no light from an approaching car will reach the eyes of a driver. Such a system is, however, complicated and there is a danger of the driver "going blind" in case of faulty operation of the shutters.

A third system of direction selection merely utilizes an alteration in the direction of the beam but it is not in harmony with the requirements of good automotive lighting.

A fourth system using polarized light seems to offer the most practical solution and will be considered more in detail. First, however, a brief discussion of the nature and properties of polarized light will be of value to those not already familiar with it.

Light,[2] according to the now accepted theory, is an electromagnetic radiation which has the properties of a wave motion in which the amplitude of the oscillation is at right angles to the direction of propagation. In natural light the vibrations are at random, that is, at all angles with respect to an axis taken in the direction of the light "ray." However, light transmitted through or reflected from certain materials have vibrations occurring only in a single plane, or in parallel planes. Such light is said to be polarized and any material used to cause light to be polarized is called a polarizer. Light may be polarized either by reflection from certain surfaces or by transmission through certain other materials, notably *Nicol prisms* and *tourmaline* crystals. In this discussion those polarizers which polarize light transmitted through them will be considered in all cases unless specifically stated otherwise.

If light which has been polarized is passed through a second polarizer (generally termed an analyzer) the amount of light transmitted depends upon the angle between the plane of polarization of the light and the direction of the polarizing plane of the analyzer. If the plane of polarization of the light and the analyzer are parallel, (almost) all of the light will be transmitted, while if they are perpendicular, (almost) none of the light will be allowed to pass through.

A simple and much used analogy of polarized light may aid in better explaining these properties of polarized light. Suppose a rope is fastened to a wall and stretched out loosely. If the free end is shaken up and down, sidewise, and at all possible angles (or, in other words, in a circular motion) the waves are at random and will simulate the waves in natural light. Now imagine that this rope is passed through a picket fence and shaken as before. Then only the vertical components of the vibrations will appear on the side of the fence toward the fastened end. In this analogy the picket fence corresponds to the polarizer. If the rope is moved only in a vertical plane the entire motion imparted to the rope will appear on the other side of the fence. A horizontal motion given

[1] K. D. Chambers, *Society of Automotive Engineers Journal* 1926, Vol. 18, p. 613.

[2] Duncan and Starling, *A Textbook of Physics*, Macmillan and Co., Ltd., London, 1931, p. 648.

to the rope will be entirely arrested beyond the fence, and if the waves are at an angle only the vertical components will be transmitted through the fence. In these last illustrations the fence corresponds to an analyzer.

Several systems have been proposed for the elimination of glare in automotive lighting by the use of polarized light.[3] One system uses all lights with horizontal polarizations and the viewing medium with vertical polarization. It depends for its success upon the depolarization of light reflected by the road surfaces. This method has been very satisfactory in eliminating the direct light but is not quite suitable in all cases because certain road surfaces do not depolarize the reflected light sufficiently. Fundamentally, this system is very inefficient since, if the light were perfectly depolarized, only about half of the light could be utilized.

In a second system vertical polarization is used in the lamps and viewing screens of the cars traveling in one direction and a horizontal polarization throughout on cars traveling in the opposite direction. This system, as with the color selection system, requires that the direction of polarization must be altered to meet the established custom of the road.

A third and more promising system has been developed by L. W. Chubb[4] which is effective and entirely automatic in operation. This system is known as the 45-degree system. In the use of this system *all* the cars would have the lamps and viewing screens polarized at an angle of 45° to the right of the vertical as viewed by the driver. Since the lamps and viewing screen have the same direction of polarization full effect is derived from the light of the headlights of the car and of those cars traveling in the same direction. A brief examination, however, will show that the direction of polarization of the lights of an approaching car is perpendicular to that of the viewing screen and therefore the light from the lamps of an oncoming car is not passed through the screen.

This system offers a practical solution to the glare difficulty. It is relatively inexpensive, does not require complicated mechanism, and does not need to in any way alter the distribution on the highway. In fact, with the adoption of this system the distribution could be altered so as to conform with the ideal without having to consider the effects upon drivers of other cars.

For use in existing equipment polarizing screens may be easily made available for use in the headlamp and a viewing screen used upon the windshield of the car. For use in new cars either polarizing screens in the lamp may be used or the same may be accomplished by a surface which polarizes reflected light. For use of small highly efficient polarizers, an ellipsoidal reflector with the lamp at one focus and the polarizer at or near the other may be used. In this case the proper light distribution is obtained by the use of directing lenses upon the lamps.

For the viewing screen, a small screen similar to the sun shades commonly used in cars may be supplied, or goggles containing the polarizing medium can be made cheaply for those who have no objection to wearing them. For the new cars the whole windshield can be made polarizing by including a laminated windshield similar to the present "safety glass" in which an intermediate layer of a plastic substance containing the polarizing crystals is used.

At the present time there is no incentive for a driver to include this equipment upon his car as it would be useless unless other cars were so equipped. There is, however, no reason why laws should not be passed requiring this equipment to be included in all cars just as there are present laws concerning other safety devices such as tail-lights, stop-lights, rearview mirrors, etc.

It should be noted that the polarizer will reduce by about 50 per cent the light available from a given lamp. However, with the general adoption of the use of this system of using polarized light, the present legislation limiting the size of lamps which may be used will be obsolete and unnecessary and it will be possible to provide even higher illumination levels upon the road.

When suitable legislation can be passed to insure proper polarization of all vehicle lamps upon the highways another of the great problems of the illuminating and automotive engineers will be nearing its practical solution.

[3] L. W. Chubb, *Polarized Light for Motor Vehicle Lighting*, Illuminating Engineering Society, New York, 1936.

[4] Graduated from The Ohio State University, College of Engineering in 1905. Now is Director of Research at Westinghouse Electric and Manufacturing Co., Pittsburgh, Pa.

FORTY-FIVE DEGREE POLARIZATION